Atmospheric Vectors

By utilizing vectors in Meteorology, information may be obtained
About reported winds by performing vector addition and subtraction.

SCALOR & VECTOR QUANTITIES.

Scalar Quantity – Any physical quantity (temperature, density, or humidity) which only has a single numerical value (magnitude).

Distance: The measurement of the separation of 2 points. Units is meters (m).

Area (A): The measurement of a 2 dimensional surface. Units is meters squared (m^2

Volume (V): The amount of space that an object occupies. Units is meters cubed (m

Speed: Displacement per unit time. Units may be a variety, knots, mph, km ….

Density (ρ): The amount of mass per unit volume. Equation is $\rho = m/V$.

Where – **ρ** is density (greek letter "rho")
m is the mass of the substance
V is the volume that it occupies

Measured in kg/m^3

SCALOR & VECTOR QUANTITIES.

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Measured in kg/m^3

Relationships -

If the mass is doubled, what happens to density?

$\uparrow\rho = \uparrow m / V$ $\downarrow\rho = \downarrow m / V$

If the volume increases to 5 times the original values, what happens to densit

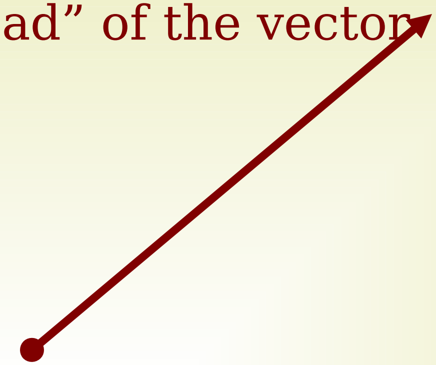
$\downarrow\rho = m / \uparrow V$ $\uparrow\rho = \downarrow m / V$

<u>SCALOR & VECTOR QUANTITIES.</u>

Vector: Any quantity which has both magnitude and direction.

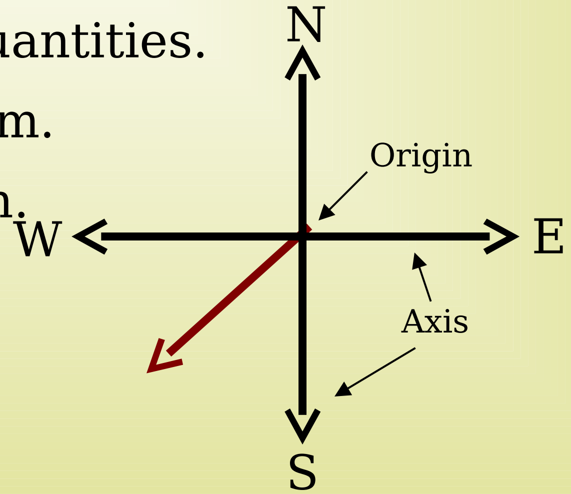
Represented Mathematically:

27008 kts



Represented Graphically:

- An arrow represents the vector.
- Arrow Length is proportional to the magnitude of the vector.
- Points in the direction the object is moving (“towards”).
- A magnitude and direction describe vector quantities.
- Plotted on the Navigational Coordinate System.
- End point of the vector is plotted at the origin.



SCALOR & VECTOR QUANTITIES.

Examples of a Vector

Velocity (v) : Displacement per unit time in a particular direction.

Average Velocity (v): Displacement over some time interval.

Equation - $|v| = |\Delta x| / |\Delta t|$

Where - $|v|$ is average velocity
$|\Delta x|$ is displacement
$|\Delta t|$ is the time interval

Relationships -

If velocity increases, what happens to displacement?

$\uparrow v = \uparrow \Delta x / \Delta t$

If velocity decreases, what happens to displacement?

$\downarrow v = \downarrow \Delta x / \Delta t$

VECTOR OPERATIONS.

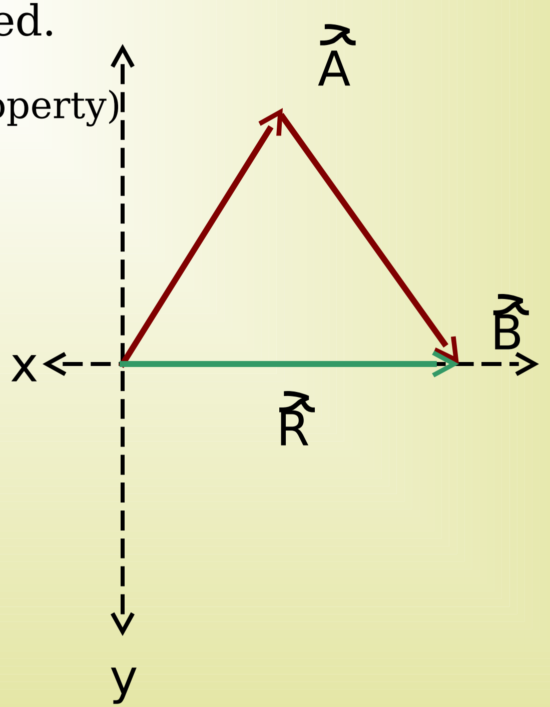
Vector Operations

Addition – Utilize graphical "head-to-tail" method

- Step #1 – Construct a x,y coordinate system.
- Step #2 – Select a scale and plot vector "A" to scale.
- Step #3 – Plot vector "B", with proper orientation using another coordinate on the head of vector "A".
- Step #4 – Draw the Resultant vector "R" from the origin of "A" to the head of the last vector plotted.

NOTE: The order of addition makes no difference (Cumulative Property)

(A + B = B + A)



Meteorological Uses

- Resultant of Forces.
- Average Wind for a Layer.

VECTOR OPERATIONS.

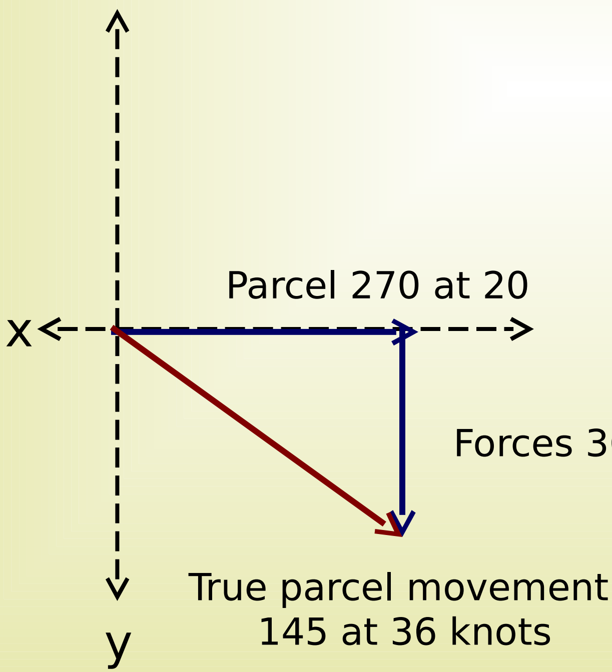
Vector Addition

Addition – Utilize graphical "head-to-tail" method.

Meteorological Uses – Resultant of Forces

• The direction of a parcel's movement can Be found by the vector sum of all forces actin Upon the parcel.

• The magnitude of change in the parcels mo Is proportional to the magnitude of the result



Ex. – A parcel of air is moving from 270 at 20 Knots. Added forces are from 360 at 30 knots.

VECTOR OPERATIONS.

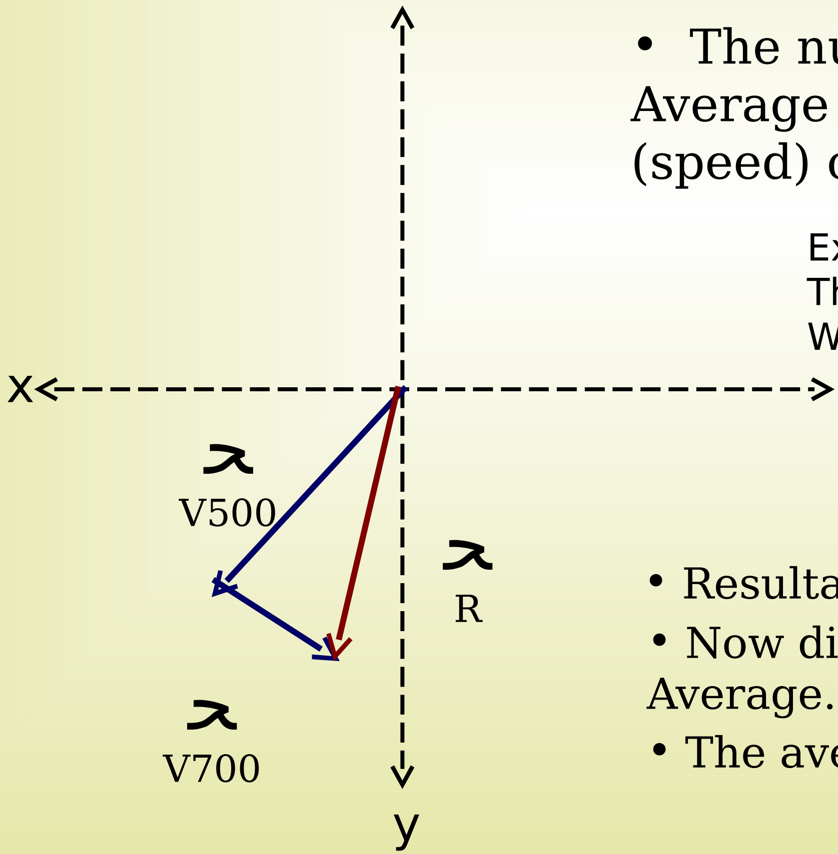
Vector Addition

Addition – Utilize graphical "head-to-tail" method.

Meteorological Uses – Average Wind for a Layer

- The number of levels added to compute the Average wind for a layer divides the magnitude (speed) of the resultant wind – (V1 + V2)/2.

Ex. – The 700mb wind is 320 at 20.
The 500mb wind is 060 at 30.
What is the average wind?



- Resultant vector is 210 at 34 knots.
- Now divide resultant speed by 2 to determine Average.
- The average wind is from 030 at 17 knots.

VECTOR OPERATIONS.

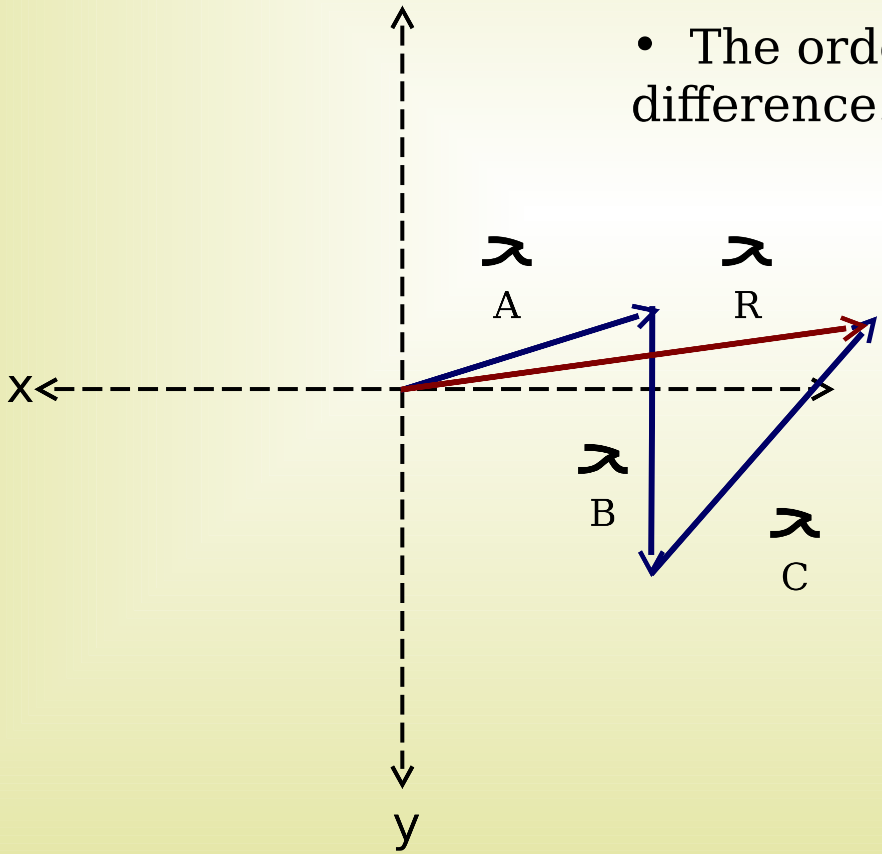
Vector Operations

Addition – Utilize graphical “head-to-tail” method.

Addition of 3 or more layers

- The order of addition does not make a difference.

$\vec{A}$ = 070 at 15 kts
$\vec{B}$ = 180 at 15 kts
$\vec{C}$ = 045 at 20 kts



$\vec{\mathbf{R}}$ Equals 080 at 28 knots

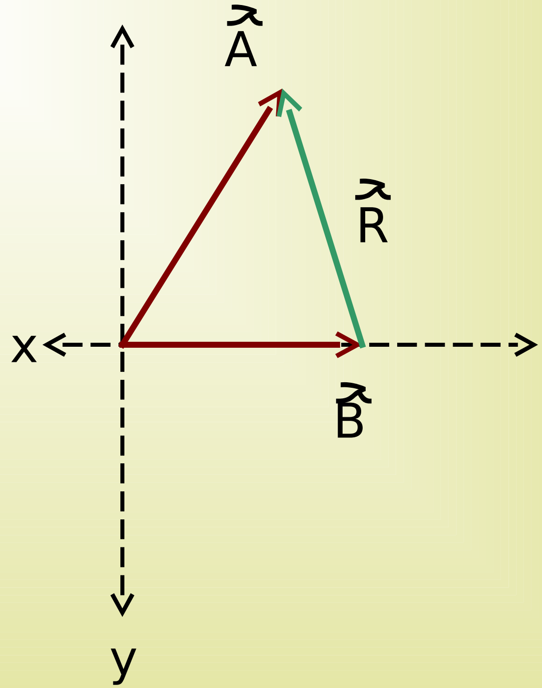
VECTOR OPERATIONS.

Vector Operations

Subtraction – Utilize graphical “Tail-to-tail” method

- Step #1 – Construct a x,y coordinate system.
- Step #2 – Select a scale and plot vector “A” and “B” to scale, with both tails at t
- Step #4 – Draw the Resultant vector “R” from the head of the vector being subt to the head of the vector being subtracted from “A” (A – B = R).

NOTE: The order of subtraction DOES make a difference (A - B ≠ B - A)



Meteorological Uses

- Wind Shear.
- Cirrus Blowoff.

VECTOR OPERATIONS.

Vector Operations

Subtraction – Utilize graphical "Tail-to-tail" method

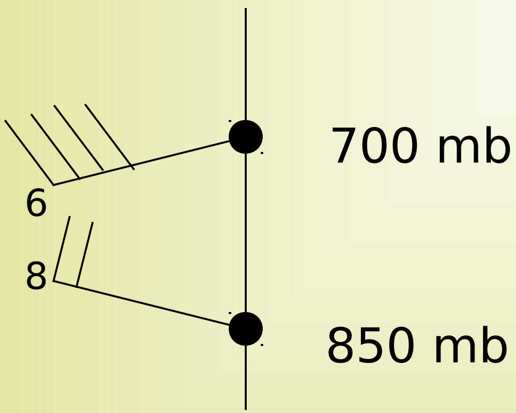
NOTE: The order of subtraction DOES make a difference

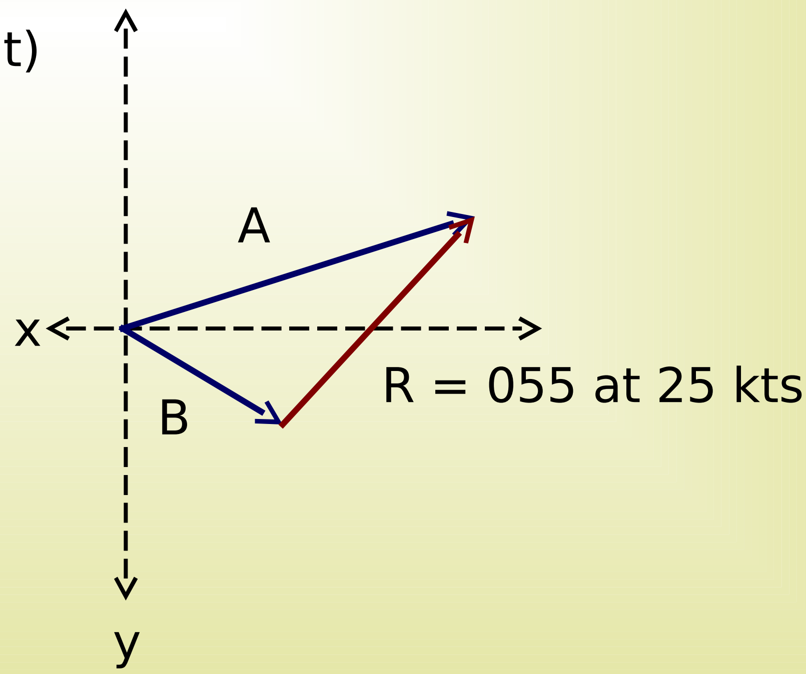
(A - B ≠ B - A)

Meteorological Uses – Wind Shear.

- Change of wind speed and/or direction in the vertical or horizontal.

700mb – 850mb = Shear (resultant)





VECTOR OPERATIONS.

Vector Operations

Subtraction – Utilize graphical “Tail-to-tail” method

NOTE: The order of subtraction DOES make a difference

(A - B ≠ B - A)

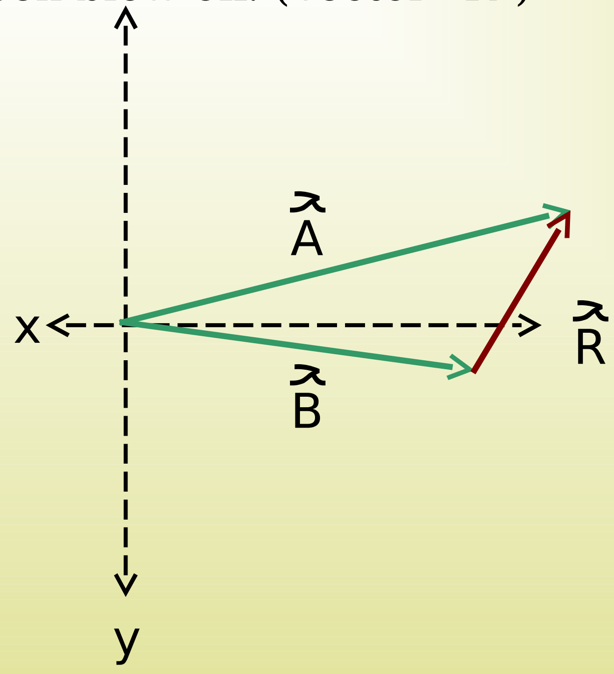
Meteorological Uses – Cirrus Blowoff.

- Wind flow aloft minus storm cell movement.
  - Cirrus starts at the origin and is blown off by the upper-level wind flow. (Vector “A”)
  - At the same time, the storm cell is moving. (Vector “B”)
  - It appears as if the cirrus has been blow off. (Vector “R”)

A = Winds aloft
from 240 at 30 kts

B = Cell Movement
towards 100 at 20 kts

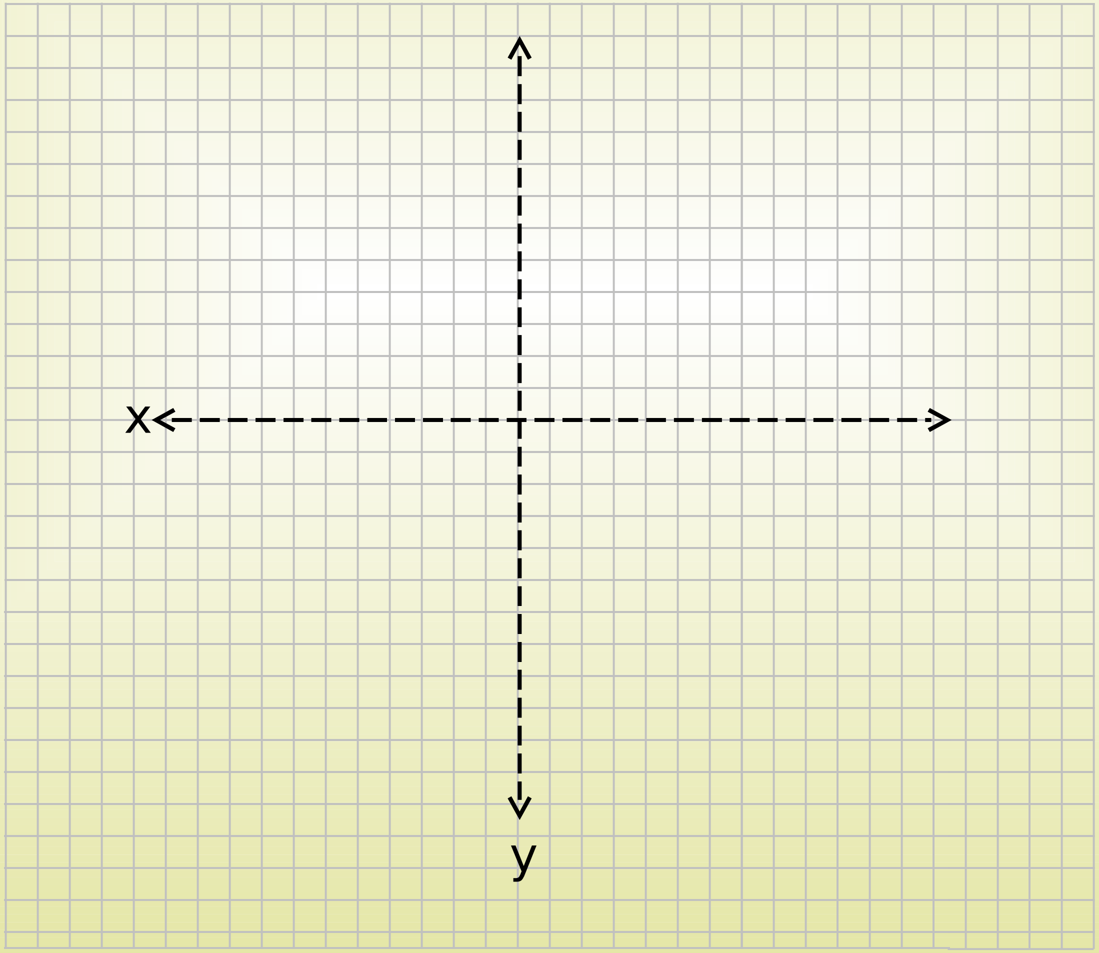
R = Cirrus Blowoff
(A – B) 020 at 19.5 kts



VECTOR OPERATIONS.

Example #1

1. Find A + B for the following. Express answer as a vector.
   a. A = 030°/50 , B = 150°/25
   b. A = 270°/30 , B = 345°/60

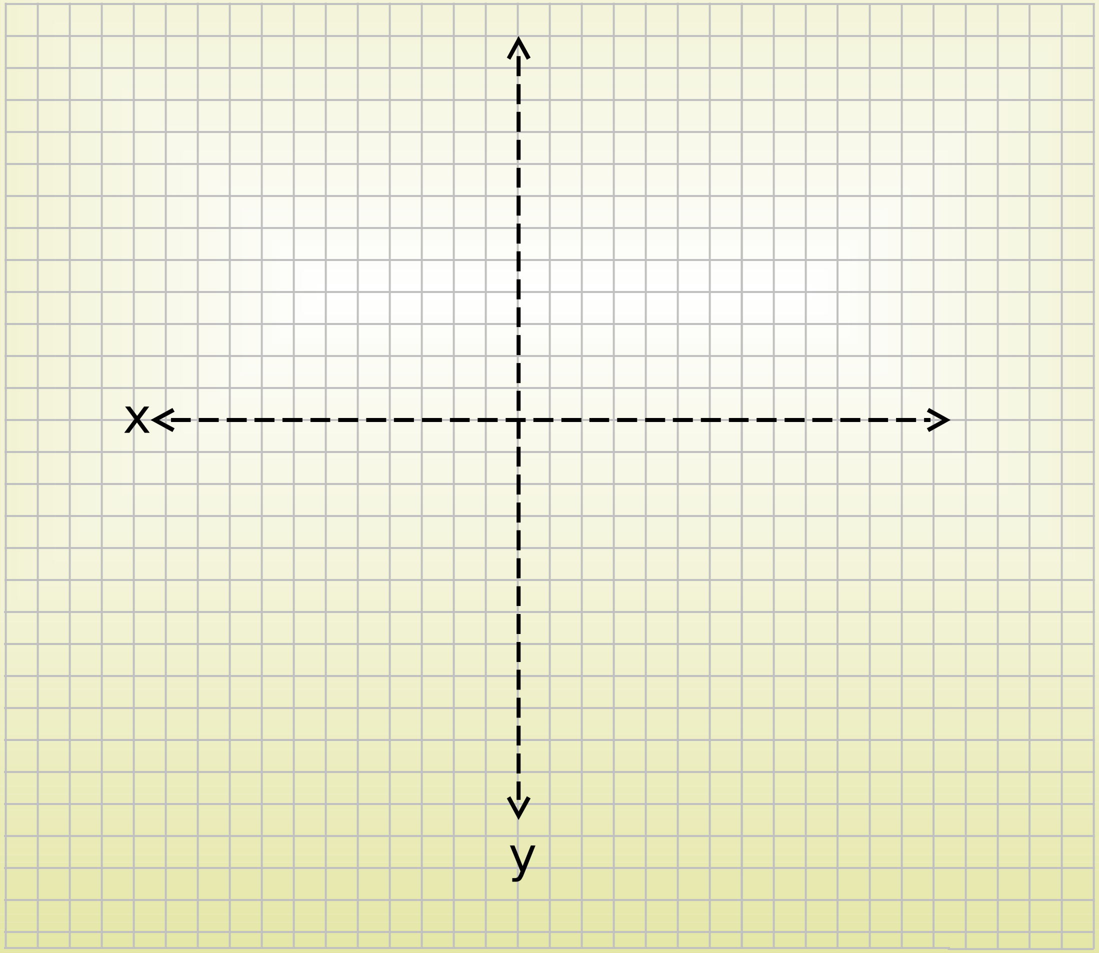


Scale: Each square represent 5 knots.

VECTOR OPERATIONS.

Example #2

1. Find the vertical wind shear between the 850 and 700mb levels if the 850mb wind e
   27020, and the 700mb equals 18020. Express as a vector.

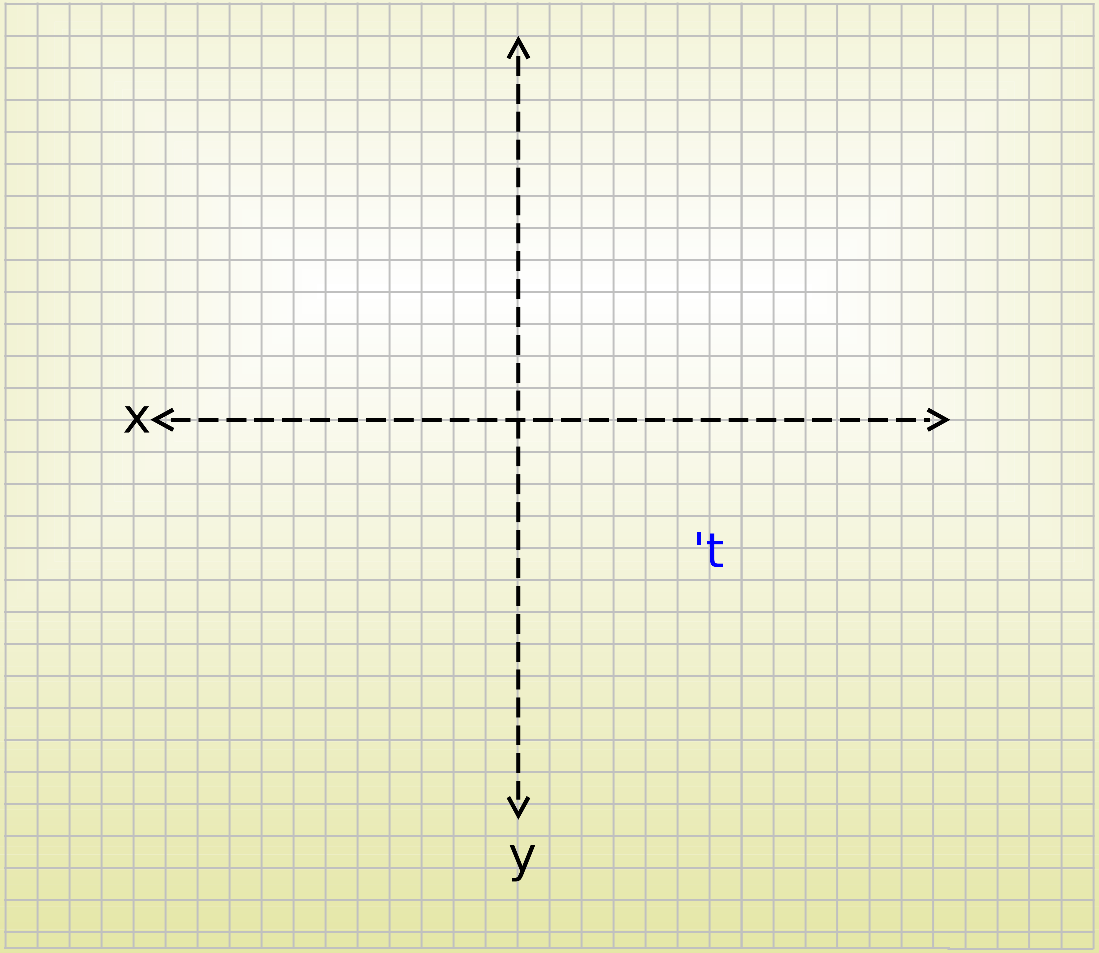


Scale: Each square represent 5 knots.

VECTOR OPERATIONS.

Example #3

1. Add the following vectors.
   A = 09010
   B = 14515
   C = 30015

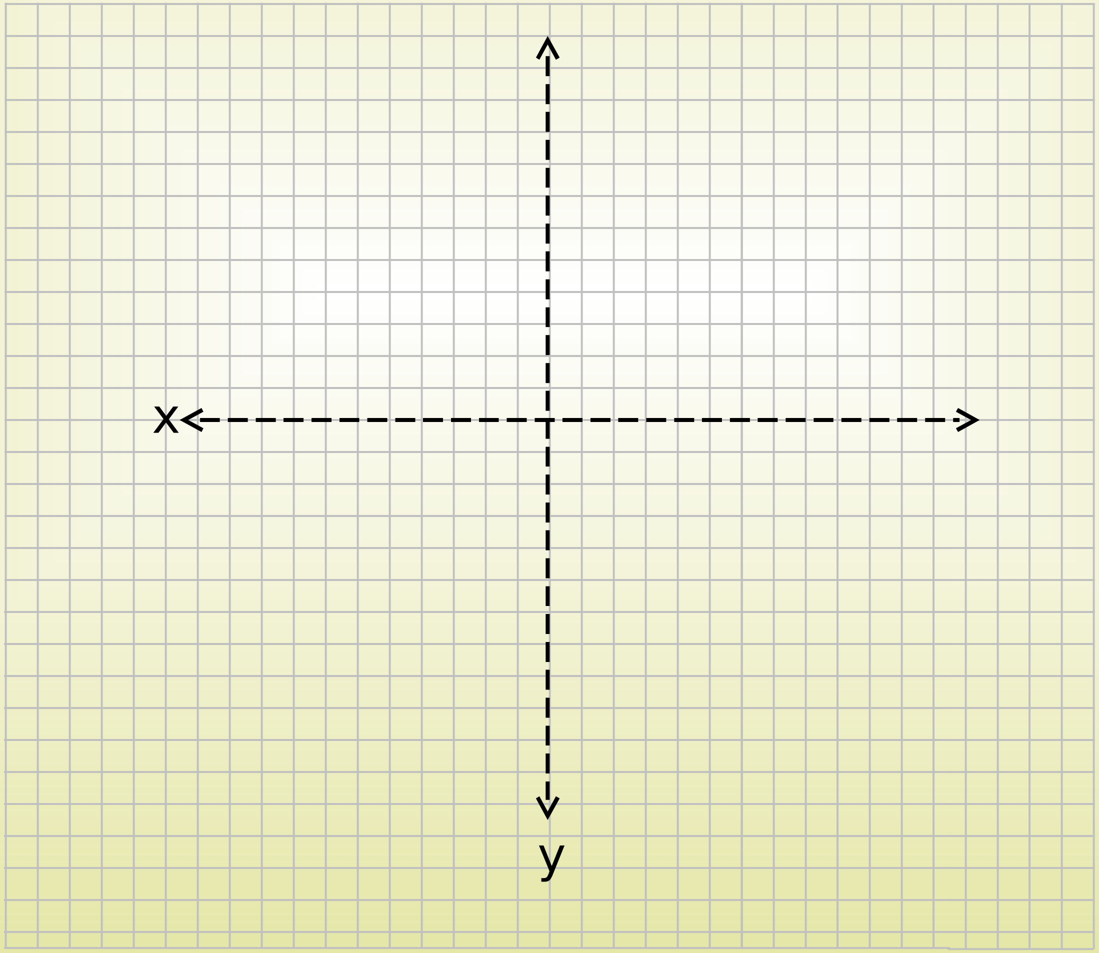


Scale: Each square represent 5 knots.

VECTOR OPERATIONS.

Example #4

1. Calculate the direction and speed of the cirrus blow-off for a thunderstorm if the prevailing wind from 270 at 50 kts and the movement of the thunderstorm is toward 360 at 30 kts.



Scale: Each square represent 5 knots.

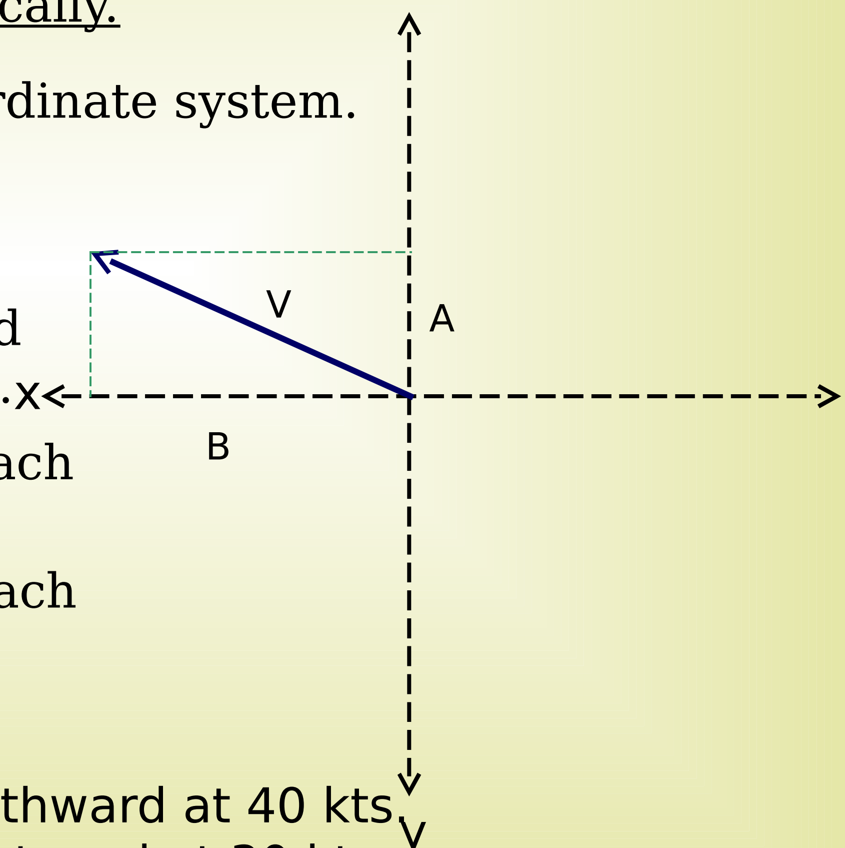
Vector Components.

Computing Components of Vectors

Component: The portion of a vector along a given coordinate system.

Determining vector components graphically.

- Step #1 – Draw a navigational coordinate system.
- Step #2 – Determine scale.
- Step #3 – Plot vector from origin.
- Step #4 – Drop a line from the head of the vector to each axis.
- Step #5 – Measure magnitude of each component.
- Step #6 – Determine direction of each component.



Component A = Northward at 40 kts.
Component B = Westward at 30 kts.

Scale
1/4” is 10 kts

Vector Components.

Computing Components of Vectors

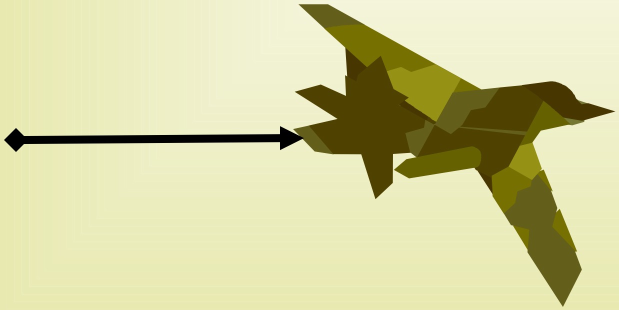
Component: The portion of a vector along a given coordinate system.

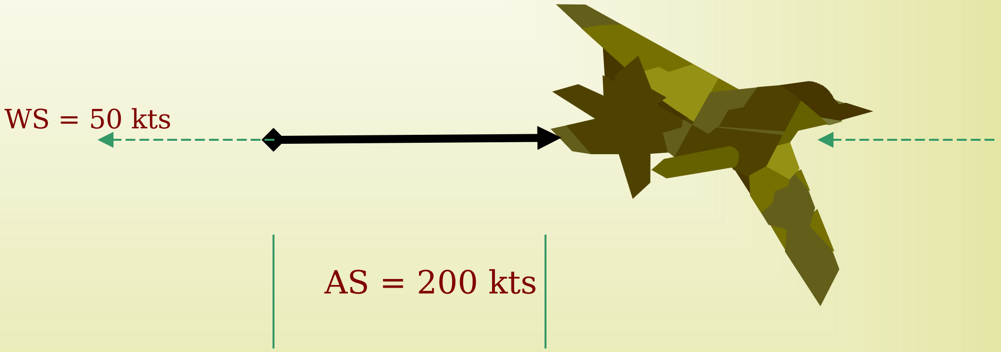
Commonly used terms with vector components:

- Air Speed – The speed at which an aircraft is flying relative to the wind.
- Ground Speed – The speed at which the aircraft is flying over, or relative to the ground.
- Head Wind – Component of the wind vector that is parallel to the aircraft's directi motion. Opposed aircraft motion decreasing ground speed.

WS = 50 ktsGS = 150 ktsAS = 200 kts

No Winds
Air Speed (AS) = Ground Speed (GS)





Air Speed – Head Wind = Ground Speed

200 – 50 =150 kts

Vector Components.

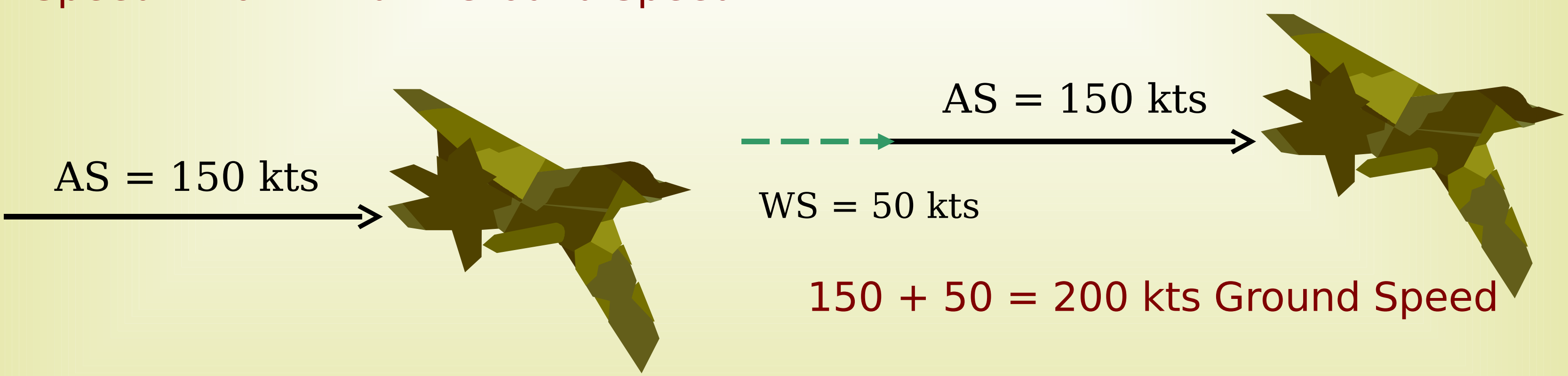
Computing Components of Vectors

Component: The portion of a vector along a given coordinate system.

Commonly used terms with vector components:

- **Tail Wind** – Component of the Wind vector that is parallel to the aircraft's directi motion. Assists aircraft motion resulting in increased ground speed.

Air Speed + Tail Wind = Ground Speed



Vector Components.

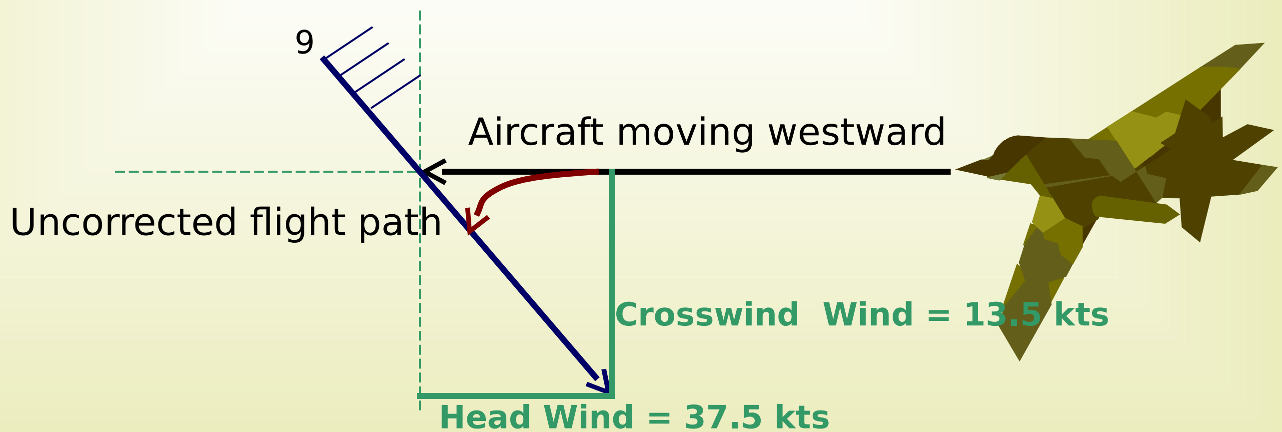
Computing Components of Vectors

Component: The portion of a vector along a given coordinate system.

Commonly used terms with vector components:

- **Crosswind** – Component of the wind perpendicular to aircraft's flight path. Requi change of aircraft heading in order to maintain desired course.

To determine the crosswind, use steps for determining vector components.



- **Runway Crosswind** – Component of the wind perpendicular to aircraft's flight p during take-off or landing. May require a change of runway for safe flight operat

Vector Components.

Computing Components of Vectors

Component: The portion of a vector along a given coordinate system.

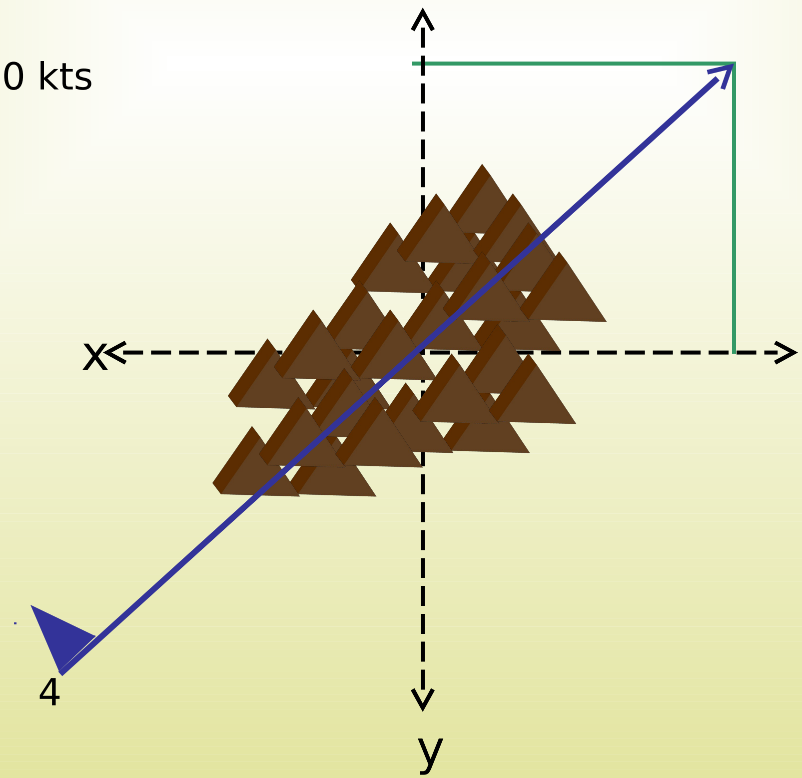
Commonly used terms with vector components:

- **Mountains** – Strength of the wind component perpendicular to the mountain ran often has a definite impact on lee-side weather and downstream turbulence.

To determine the mountain crosswind, use steps for determining vector component

Observed Wind = 240 at 50 kts

Component Perpendicular
to range = 090 at 30 kts



Questions

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Presentation made by GySgt K.L. Hubler